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(71) Applicant
**Toshiba Kikai Kabushiki Kaisha**

**(Incorporated in Japan)**

**2-11 Ginza 4-chome, Chuo-ku, Tokyo-to, Japan**

(72) Inventor
**Kuzuhito Sato**

(74) Agent and/or Address for Service
**A R Davies & Co**
**27 Imperial Square, Cheltenham, GL50 1RQ, United Kingdom**

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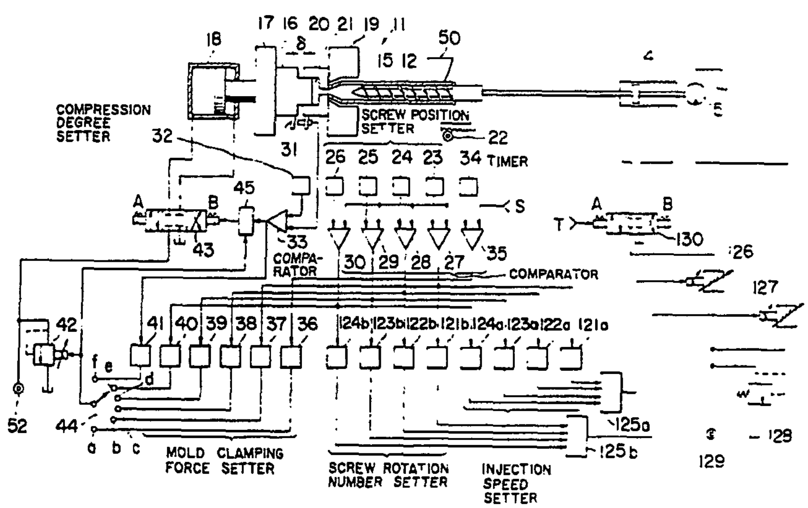
# (54) Controlling injection moulding machine

(57) In a method of operating an injection compression molding machine comprising a stationary mold 20, a movable mold 16, an oil pressure actuator 18 for advancing the movable mold toward the stationary mold to form a mold cavity 21 therebetween with a predetermined compression clearance δ, a cylinder 15 adapted to engage with the stationary metal mold 20, a screw 12 located in the cylinder for injecting resin into the mold cavity 21, an oil pressure motor 5 for rotating the screw 12 and a piston cylinder unit 4 for reciprocating the screw through the cylinder 15, the molten resin is fed into the mold cavity 21 by advancing the screw 12 and the advancement of the movable mold 16 is started when the screw 12 reaches a predetermined set position during an injection stroke so as to reduce the compression clearance δ and to increase the pressure acting upon the molten resin injected into the mold cavity.

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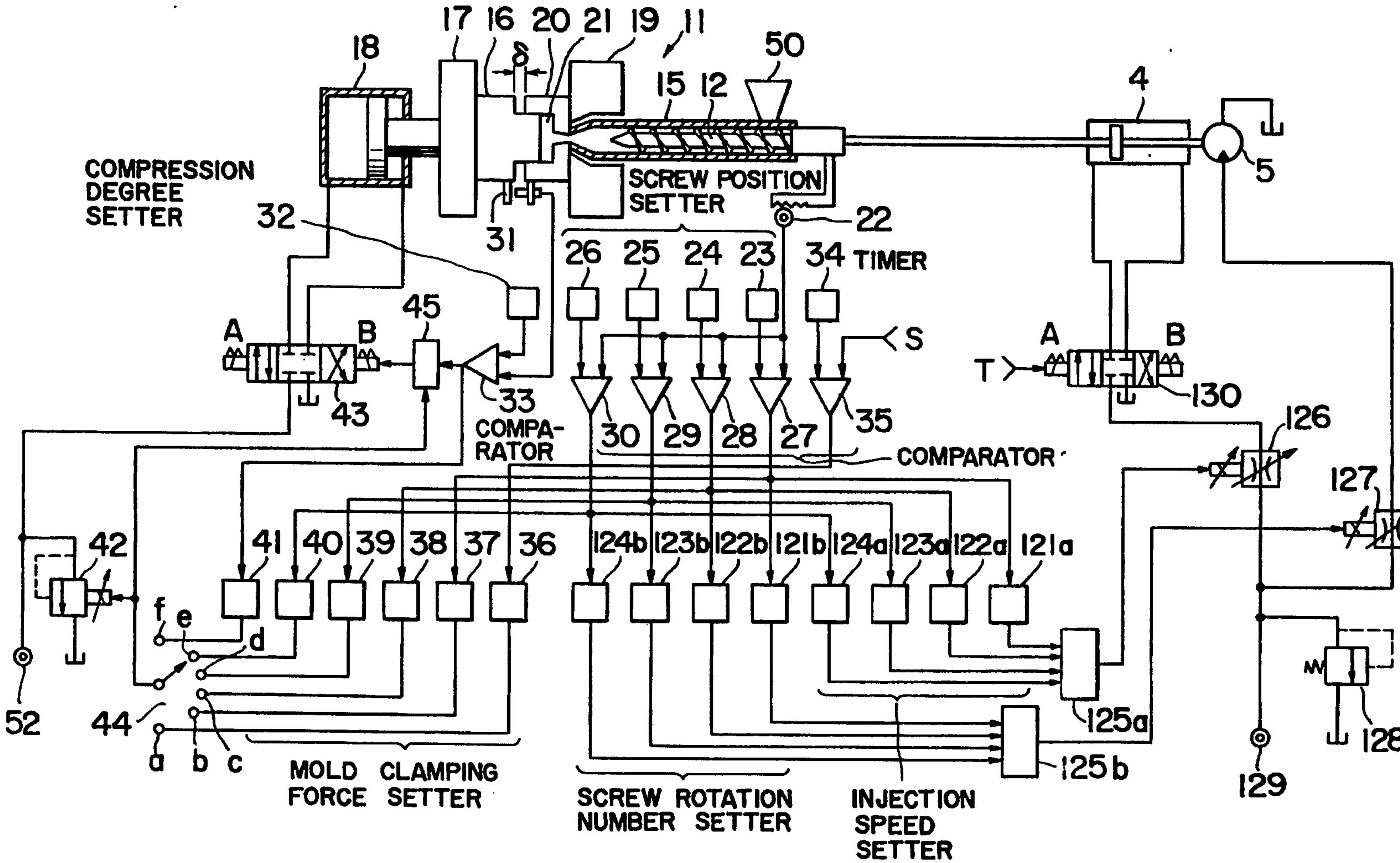

COMPRESSION DEGREE SETTER
18
17
16
δ
20
21
19
11
15
12
50
4
5
SCREW POSITION SETTER
22
31
32
26
25
24
23
34
TIMER
S
A
B
45
T
130
33
COMPA-RATOR
43
30
29
28
27
35
COMPARATOR
126
127
42
41
40
39
38
37
36
124b
123b
122b
121b
124a
123a
122a
121a
f
e
d
52
44
a
b
c
125a
125b
128
129
MOLD CLAMPING FORCE SETTER
SCREW ROTATION NUMBER SETTER
INJECTION SPEED SETTER

2214125

# METHOD AND APPARATUS FOR INJECTION MOLDING

## BACKGROUND OF THE INVENTION

For molding, with an injection molding machine, such products as lenses and discs having a relatively large thickness and required to have precise configurations and small internal strains, an injection molding machine has been used capable of injecting a large quantity of molten material in each shot such that the quantity of the molten material injected into a mold cavity of a metal mold would not be deficient. For this reason, a method and apparatus have been used wherein a movable metal mold is positioned in a stationary metal mold with a small gap or compression clearance left therebetween, molten resin is filled in the mold cavity defined between the movable and stationary metal molds, and then the movable metal mold is advanced to close the gap or reduce to zero the compression clearance. However, this compression movement is started immediately after filling the molten resin into the mold cavity, or a predetermined time after completion of the filling of the molten resin. For this reason, the compression starting time substantially lags the filling starting time with the result that the molten resin injected into the mold cavity solidifies starting from the contact surface between the resin and the metal mold. Accordingly, when the compression is continued

under this condition, it is inevitable to create an internal stress in the molded product.

In the prior art method wherein the compression clearance is reduced after filling the molten resin, a large mold clamping force is necessary thus increasing the size of the injection molding machine. Where a molding machine requires a small mold clamping force but it is necessary to increase the quantity of the injected resin per shot, the screw is rotated while being advanced toward the metal mold.

With this method, however, the molten resin is conveyed into the mold cavity only by the transfer force caused by the rotation of the screw so that where the cavity has an intricated configuration, the resin cannot reach deep portions of the cavity. Moreover, as the filling speed of the resin is relatively low, there is the same defect that the resin begins to solidify starting from the contact surface between the filled resin and the metal mold.

## SUMMARY OF THE INVENTION

It is an object of this invention to provide an improved method and apparatus capable of preventing creation of the internal strain in the molded product due to a lag of the compression motion of the movable metal mold.

Another object of this invention is to provide an improved method and apparatus capable of manufacturing

products of an intricated configuration with an injection molding machine requiring a relatively small mold clamping force.

According to one aspect of this invention there is provided a method of operating an injection compression molding machine comprising a stationary metal mold, a movable metal mold, an oil pressure actuator for advancing the movable metal mold toward the stationary metal mold to form a mold cavity therebetween with a predetermined compression clearance δ left between the movable and stationary metal molds, a heating cylinder adapted to engage with the stationary metal mold, means for supplying a thermoplastic resin into the heating cylinder, a screw contained in the heating cylinder for injecting molten metal into the mold cavity, means for rotating the screw and means for reciprocating the screw through the heating cylinder, characterized in that the method comprises the steps of filling the molten resin in the mold cavity and starting advancement of the movable metal mold toward the stationary metal mold when the screw reaches a predetermined set position during an injection stroke so as to reduce the compression clearance δ and to increase pressure acting upon the molten resin injection into the mold cavity.

According to another aspect of this invention there is provided apparatus for operating an injection compression molding machine comprising a stationary metal

mold, a movable metal mold, an oil pressure actuator for advancing the movable metal mold toward the stationary metal mold to form a mold cavity therebetween with a predetermined compression clearance $\delta$ left between the movable and stationary metal molds, a heating cylinder engaging the stationary metal mold, means for supplying a thermoplastic resin into the heating cylinder, a screw contained in the heating cylinder for injecting molten resin into the mold cavity, means for rotating the screw and means for reciprocating the screw in the heating cylinder, characterized in that the apparatus comprises a screw position detector for detecting the axial position of the screw, a plurality of screw position setters respectively setting predetermined screw positions along which the screw is moved, a plurality of comparators respectively comparing the outputs of the screw position setters with the output signal of the screw position detector, a plurality of mold clamping force setters connected to receive output signals of the respective comparators, a transfer switch for selecting one of the outputs of the mold clamping force setters, and an electromagnetic transfer valve energized by the output of the transfer switch through a control device for actuating the oil pressure actuator.

## BRIEF DESCRIPTION OF THE DRAWING

In the accompanying drawing a single figure shows an injection molding machine and electric and hydraulic

circuits for operating th injection molding machine according to this invention.

## DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to the accompanying drawing, the compression type injection molding machine 11 embodying the invention comprises a screw 12 reciprocated by an injection cylinder 4 and rotated by an electric or an oil pressure motor 5. The screw 12 is contained in a heating cylinder 15 having a hopper 50 at one end for charging a thermoplastic resin. The injection molding machine further comprises a movable metal mold 16 mounted on a movable plate 17, the movable metal mold being moved toward and away from a stationary metal mold 20 supported by a stationary plate 19 when a mold clamping cylinder 18 is operated so as to engage with the stationary metal mold 20 to define a mold cavity 21. The cavity 21 is defined such that when movable metal mold 16 is inserted into the stationary metal mold 20 a compression clearance or gap $\delta$ would be left therebetween so that the clearance $\delta$ is closed or reduced to zero while the molten resin is filled into the mold cavity. A position detector 22 is provided for detecting an axial position of screw 12, which may be a potentiometer, for example. There are also provided screw position setters 23 - 26 which are set with any desired screw positions respectively and comparators 27 - 30 which respectively compare the output of the screw position detector 22 and the outputs of

scr w position setters 23 - 26 for producing signals for controlling the screw speed at any one of the set screw positions and the mold clamping force.

There are provided a clearance detector 31 mounted on the movable and stationary metal molds, a compression degree setter 32 which sets a desired clearance δ and a comparator 33 comparing the output of clearance detector 31 and the set value of the clearance δ. The comparator 33 outputs a signal when the detected value of δ exceeds the set value of δ. A timer 34 is provided for setting the rotation time of the screw, that is the filling time of the molten resin. A comparator 35 compares the output signal of timer 34 and a signal S representing an interval after start of the rotation of screw 12. There are provided a plurality of mold clamping force setters 36 - 41 which are respectively inputted with the outputs of comparators 27 - 30, 33 and 35; a transfer switch 44 having a plurality of stationary contacts a - f which are respectively connected to the output terminals of mold clamping force setters 36 - 41 and a movable contact which is operated manually to select either one of the stationary contacts a - f or automatically when either one of the mold clamping force setters 36 - 41 is set.

42 shows an electromagnetic releaf valve which relieves a portion of the pressurized oil outputted from an oil pump 52 to supply oil of a constant pressure to the mold clamping cylinder 18 via an electromagnetic

transfer valve 43 of the well known construction and controlled by a signal from a controller 45 supplied with the output signals of comparator 33 and transfer switch 44. Thus, the controller 45 controls the electromagnetic transfer valve 43 in accordance with the deviation of clearance δ and the output of one of the mold compression force setters 36 - 41, thereby applying an optimum mold clamping force to the movable metal mold 16.

A plurality of injection speed setters 121a - 124a and a plurality of screw rotation number setters 121b - 124b are respectively connected in parallel to mold clamping force setters 36 - 40. In other words, the injection speed setters 121a - 124a and screw rotation number setters 121b - 124b are supplied with the output signals of comparators 27 - 30, respectively.

The output signals of injection speed setters 121a - 123a are applied to input terminals of an OR gate circuit 125a, while the output signals of screw rotation number setters 121b - 124b are supplied to input terminals of another OR gate circuit 125b. The output signals of the OR gate circuits 125a and 125b are respectively supplied to the operating solenoids of electromagnetic throttle valves or flow quantity control valves 126 and 127. A portion of the pressurized oil outputted by an oil pump 129 is relieved by a relief valve 128 so that pressurized oil of a constant pressure is supplied to the oil pressure motor 5 through flow quantity control valve 127

and to injection cylinder 4 through flow quantity control valve 126 and electromagnetic transfer valve 130.

Although in this embodiment, the position of the screw is fixed by oil pressure means, such position fixing can also be made with mechanical means.

In operation, when the filling step is completed the screw reaches the forward limit position. Then the metal mold is opened by moving the movable metal mold 16 to the left to take out the molded product. After that, metal molds are partially closed while leaving a predetermined compression clearance $\delta$ therebetween as shown in the drawing. For preparing the next filling step, the molten resin is stored in a space in the heating cylinder 15 in front of screw 12 by rotating the same. Then the screw is retracted by the cylinder 4 while being rotated by oil pressure motor 14. When the screw position detector 22 detects a predetermined screw position, not shown, the signal T is issued so that the electromagnetic transfer valve 130 is moved to position B to block the pressurized oil discharged from the injection cylinder 4. Consequently, the screw 12 continues to rotate at that predetermined position, whereby the molten resin is accumulated in the space in front of the screw for an interval set by the timer 34. After elapse of a time set by the timer 34, the electromagnetic transfer valve 130 is brought to position A to advance the screw 12 by injection cylinder 4 so as to inject the molten resin

accumulated in the space in front of the screw into the mold cavity 21 under a high pressure. As the screw reaches a predetermined position, for example a position set by screw position setter 26, and during the injection stroke the mold clamping cylinder 18 is actuated to clamp together the stationary and movable metal molds 20 and 16 so as to decrease the clearance $\delta$.

With the method and apparatus of this invention, at the time of compression molding, the stationary and movable metal molds are closed with a predetermined compression clearance $\delta$ left therebetween, and the molten resin is filled in the mold cavity by the rotation of the screw 12 or by a combination of the rotation and the advancement of the screw. Consequently, the problem of insufficient quantity of the injected resin at each shot and the problem of creating interval stress can be solved. Moreover, it is possible to increase the injected quantity by using an injection molding machine of a relatively small capacity.

WHAT IS CLAIMED IS:

1. A method of operating an injection compression molding machine comprising a stationary metal mold, a movable metal mold, an oil pressure actuator for advancing said movable metal mold toward said stationary metal mold to form a mold cavity therebetween with a predetermined compression clearance $\delta$ left between said movable and stationary metal molds, a heating cylinder adapted to engage with said stationary metal mold, means for supplying a thermoplastic resin into said heating cylinder, a screw contained in said heating cylinder for injecting molten resin into said mold cavity, means for rotating said screw, and means for reciprocating said screw through said heating cylinder, said method comprising the steps of:

filling said molten resin in said mold cavity; and

starting advancement of said movable metal mold toward said stationary metal mold when said screw reaches a predetermined set position during an injection stroke so as to reduce said compression clearance $\delta$ and to increase pressure acting upon said molten resin injected into said mold cavity.

2. The method according to claim 1 wherein said advancement of said movable mold is started when said movable metal mold is urged by said molten metal injected

into said mold cavity thereby tending to increase said compression clearance.

3. The method according to claim 1 wherein said advancement of said movable metal mold is started by a timer which starts its operation when said screw reaches a predetermined position.

4. A method of operating an injection compression molding machine comprising a stationary metal mold, a movable metal mold, an oil pressure actuator for advancing said movable metal mold toward said stationary metal mold to form a mold cavity therebetween with a predetermined compression clearance $\delta$ left between said movable and stationary metal molds, a heating cylinder adapted to engage with said stationary metal mold, means for supplying a thermoplastic resin into said heating cylinder, a screw contained in said heating cylinder for injecting molten resin into said mold cavity, means for rotating said screw, and means for reciprocating said screw through said heating cylinder, said method comprising the steps of:

accumulating molten resin in a space in said heating cylinder in front of said screw by rotating said screw;

injecting said accumulated molten resin into said mold cavity by rotating said screw; and

advancing said movable m tal mold toward said stationary metal mold for reducing said compression clearance δ and for increasing pressure applied to said molten metal injected into said mold cavity.

5. The method according to claim 4 further comprising the step of advancing said screw while said screw is rotated for injecting said accumulated molten resin into said mold cavity.

6. The method according to claim 4 wherein said compression molding is started at a predetermined point during rotation of said screw.

7. The method according to claim 4 wherein said pressure molding is started at a predetermined point during advancement of said screw.

8. The method according to claim 4 wherein said compression molding is started when said compression clearance is caused to increase by said molten resin injected into said mold cavity.

9. In apparatus for operating an injection compression molding machine comprising a stationary metal mold, a movable metal mold, an oil pressure actuator for advancing said movable metal mold toward said stationary

metal mold to form a mold cavity therebetween with a predetermined compression clearance δ left between said movable and stationary metal molds, a heating cylinder engaging said stationary metal mold, means for supplying a thermoplastic resin into said heating cylinder, a screw contained in said heating cylinder for injecting molten resin into said mold cavity, means for rotating said screw, and means for reciprocating said screw in said heating cylinder, the improvement comprizing:

a screw position detector for detecting an axial position of said screw;

a plurality of screw position setters respectively setting predetermined screw positions along which said screw is moved;

a plurality of comparators respectively comparing outputs of said screw position setters with an output signal of said screw position detector;

a plurality of mold clamping force setters connected to receive output signals of said respective comparators;

a transfer switch for selecting one of outputs of said mold clamping force setters; and

an electromagnetic transfer valve energized by an output of said transfer switch through a control device for actuating said oil pressure actuator.

10. The apparatus according to claim 9 which further comprises a clearance detector which detects said compression clearance $\delta$, a compression degree setter provided for said movable and stationary metal molds, a comparator for comparing output signals of said clearance detector and said compression degree setter, and means for applying an output signal of said comparator to said control device.

11. The apparatus according to claim 9 which further comprises a timer for setting a rotation time of said screw, another comparator which compares an output signal of said timer with a signal S representing an interval after start of rotation of said screw, and another mold clamping force setter energized by said another comparator which produces an output signal selected by said transfer switch.

12. The apparatus according to claim 9 which further comprises a plurality of screw rotation number setters respectively connected to receive outputs of said comparators, an OR gate circuit inputted with outputs of said screw rotation number setters, and an electromagnetic flow control valve energized by outputs of said screw rotation number setters for operating said screw rotating means.

13. The apparatus according to claim 9 which further comprises a plurality of injection speed setters which are respectively connected in parallel with said plurality of mold clamping force setters, an OR gate circuit inputted with output signals of said plurality of injection speed setters and an electromagnetic flow control valve controlled by an output signal of said OR gate circuit for controlling quantity of pressurized oil supplied to said oil pressure actuator.

14. The apparatus according to claim 12 which further comprises an electromagnetic transfer valve actuated by a signal from a timer and interposed between said oil pressure actuator and said electromagnetic flow control valve for supplying and discharging said pressurized oil to and from said oil pressure actuator.

15. A method of operating an injection compression molding machine substantially as hereinbefore described with reference to the accompanying drawing.

16. Apparatus for operating an injection compression molding machine substantially as hereinbefore described with reference to the accompanying drawing.

Amendments to the claims
have been filed as follows

advancing said movable metal mold toward said stationary metal mold for reducing said compression clearance $\delta$ and for increasing pressure applied to said molten metal injected into said mold cavity.

5. The method according to claim 4 further comprising the step of advancing said screw while said screw is rotated for injecting said accumulated molten resin into said mold cavity.

6. The method according to claim 4 wherein said compression molding is started at a predetermined point during rotation of said screw.

7. The method according to claim 4 wherein said pressure molding is started at a predetermined point during advancement of said screw.

8. The method according to claim 4 wherein said compression molding is started when said compression clearance is caused to increase by said molten resin injected into said mold cavity.

9. Apparatus for carrying out the method of claim 1 in an injection compression molding machine comprising a stationary metal mold, a movable metal mold, an oil pressur actuator for advancing said movable metal mold toward said stationary metal mold to form a mold cavity

therebetween with a predetermined compression clearance $\delta$ left between said movable and stationary metal molds, a heating cylinder engaging said stationary metal mold, means for supplying a thermoplastic resin into said heating cylinder, a screw contained in said heating cylinder for injecting molten resin into said mold cavity, means for rotating said screw, and means for reciprocating said screw in said heating cylinder, the apparatus comprising:

a screw position detector for detecting an axial position of said screw;

a plurality of screw position setters respectively setting predetermined screw positions along which said screw is moved;

a plurality of comparators respectively comparing outputs of said screw position setters with an output signal of said screw position detector;

a plurality of mold clamping force setters connected to receive output signals of said respective comparators;

a transfer switch for selecting one of outputs of said mold clamping force setters; and

an electromagnetic transfer valve energized by an output of said transfer switch through a control device for actuating said oil pressure actuator.



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